A STUDY OF SKULL FRACTURES IN

CASES OF FALL FROM HEIGHT

Dissertation

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CONTENTS

INTRODUCTION

Nowadays deaths and injuries caused by falling from height are becoming common in urban areas. Deaths arising from fall from height can be suicidal homicidal, accidental and misadventures.

In all cases of fall from height whether it is suicidal, homicidal (or) accidental, the determination of anatomical site of impact on to the ground, i.e. (The Primary Impact Site) would be useful in the reconstruction of the fall. But this is not an easy task because of multiplicity of injuries, and when great height is involved, the contact of the body with the protruding objects of the building would cause additional injuries. However, in some cases, we can distinguish the primary impact site amongst the injuries. For example: presence of compound comminuted calcaneal fracture and tarsal & metatarsal fractures indicating that the primary impact site is feet, and also presence of overwhelmingly predominant head injuries would indicate that the primary impact site is the Head.

Generally in cases of fall from height, the body of the victim would bear almost all the types of injuries like abrasions, contusions, Lacerations, penetrating wounds, fractures, intra abdominal injuries etc. Amongst injuries, fracture skull is the predominant injury In all cases of fall from height, because skull fracture could occur even though the height of fall is less. For example: A fall from a height of 34 inches is sufficient to produce skull fracture in infants and in adults too skull fractures have certainly occurred in cases of fall on the very hard surface even from only a height of one foot. There are well authenticated instances of skull fracture and brain damage from trivial falls including some medically witnessed falls from table and settees.

The type of skull fracture varies in cases of fall from height depending upon the site of impact i.e. a ring fracture of base of the skull would occur if the primary impact site is feet (or) buttocks, and in cases of fall on head there would be a comminuted (or) depressed fracture.

Regarding the height of fall, some authors have mentioned that the severity of injuries are not necessarily being directly related to the distance that the person falls. Many people die after falling from standing position yet others some time survive a fall of many meters. Also it must be remembered that biological and circumstantial variability allow for some remarkable escape from falls.

In this study, an attempt is made to correlate the height of fall to severity of injuries to determine the height of fall, from autopsy findings of such deaths; this fact could be of great investigative value particularly in cases where the height of fall is unknown (or) if there is

a discrepancy between severity of injury and the alleged height of fall.

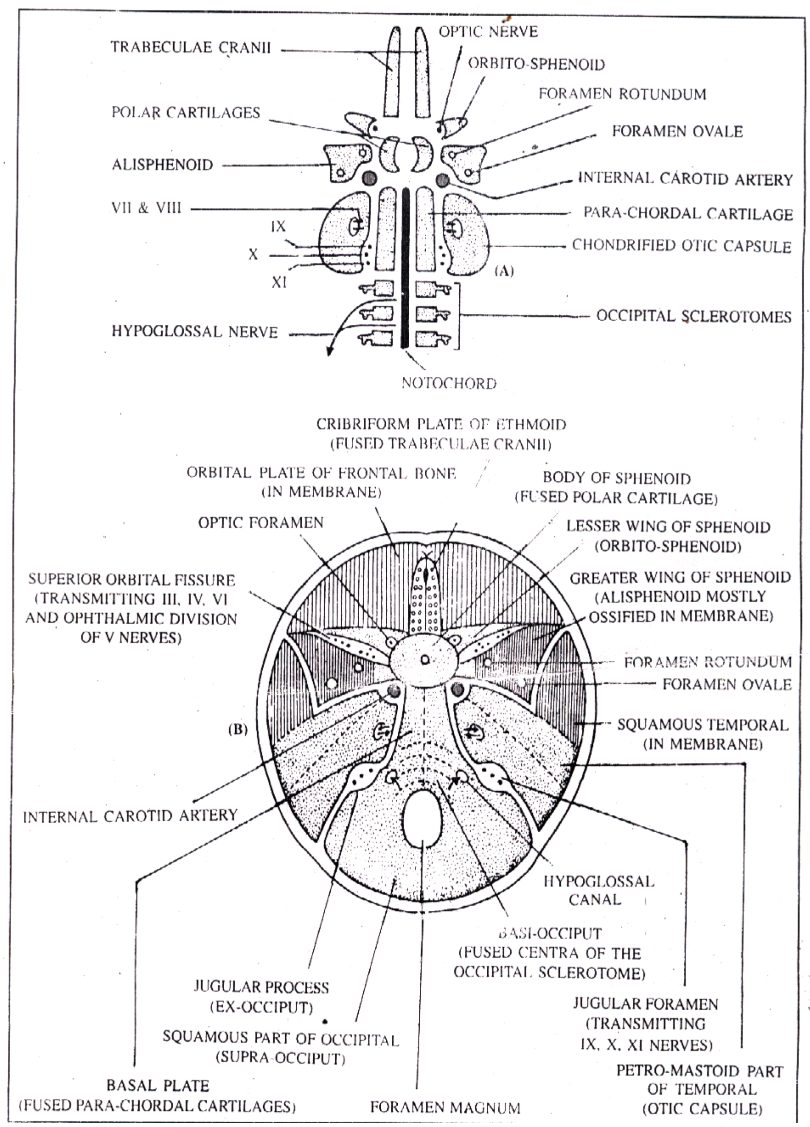
AIM

- **To study various types of skull fractures in case of fall from height .**
- **To correlate brain injury with Skull fracture in cases of fall from height.**
- **To study various injuries other than skull fractures in cases of fall from height.**

To correlate the height of fall and severity of injuries

REVIEW OF LITERATURE

The bones of the skull are developed in the mesenchyme which. surrounds the cerebral vesicles but, before the osseous state is reached, the cranium



Components of the Chondrocranium

passes through blastemal and cartilaginous Stages like other parts of the skeleton. However, not all parts pass through a phase of chondrification, and hence the chondrocraniun is incomplete, the remainder comprising the mescnchymatous, blastemal desmocranium. Most of the cranial vault and limited parts of its base are thus not preformed in cartilage. Though the mesenchymatous (membranous) and cartilaginous parts of the skull will, for convenience, be considered in sequence, they develop together and complement each other in forming the complete cranium, some of whose bones are composite structures derived from both sources- All elements, of course, pass first through a mesenchymatous phase.

THE DESMOCRANIUM

The blastemal skull (desmocranium) begins to appear at the end of the first month as a condensation and thickening of the mesenchyme which surrounds the developing brain, forming localized -masses which are the earliest distinguishable cranial elements. The first masses evident are in the occipital region, outlining the basilar (ventral) part of the occipital bone. These form an occipital plate, from which two extensions on each side grow laterally and spread to complete a foramen around each hypoglossal nerve. At the same time the mesenchymal condensation extends forwards,dorsal to the pharynx, to reach the primordium of the hypophysis,thus establishing the clivus of the cranial base and the dorsum sellae of the future sphenoid bone. Early in the second month it surrounds the developing stalk of the hypophysis and extends ventrally and rostrally between the two halves of the nasal cavity, where it forms the annalge of the ethmoid bone and of the nasal septum. The notochord traverses the ventral occipital plate obliquely, being at first near its dorsal surface and then lying ventrally, where it comes into close relationship to the epithelium of the dorsal wall of the pharynx, being for a time fused with it. It then re-enters the cranial base and runs rostrally to end just caudal to the hypophysis

During the fifth week bilateral otocysts (auditory vesicles) become enclosed in their mesenchymal otic capsules., which soon differentiate into dorsolateral vestibular and ventromedial cochlear parts, enveloping the primordia of the semicircular canals and the cochlea. Between these two regions the facial nerve lies in a deep groove. The otocysts fuse with the lateral processes of the occipital plate, leaving a wide hiatus through which the internal jugular vein and the glossopharyngeal, vagus and accessory nerves pass. At this stage the mesenchyme around the developing hypophysial stalk, which is forming the rudiment of the post sphenoid part of the sphenoid bone, spreads out laterally to form the future greater wings of this element. Smaller processes rostral to this indicate the sites of the lesser wings of the sphenoid, while other condensations reach the sides of the nasal cavity and also blend with the still mesenchymatous septum.

The first signs of the vault or upper neurocranial part of the skull appear about the thirtieth day, they consist of curved plates of mesenchyme at the sides of the skull and gradually extend cranially to blend with each other; they also extend towards and reach the base of the skull, which will become part of the chondrocranium The. skull consists of two parts—the neurocranium, and the splanchnocranium (viscerocranium). The neurocranium covers and protects the.brain; the splanchnocranium forms the facial skeleton. In the process of evalution, the neurocranium is inversely proportional to the splanchnocranium; this means that when the neurocranium enlarges, the splanchno cranium is progressively reduced.

The Neurocranium

The developing brain is enveloped by mesenchymal condensation which is differentiated into the endomeninx and the ectomeninx From the endomeninx develop the pia and arachnoid maters. Inner layer of the ectomcninx forms the dura mater, and its outer layer develops into the cranial bones. Most of the bones at the base of the skull are preformed in cartilage; hence they are collectively known as the chondrocranium. 'The bones forming the vault and the side wall of the skull are ossified directly in membrane; these are known as the membrane or dermal bones.

Some bones, however, are ossified partly, in cartilage and partly in membrane.

THE CHONDROCRANIUM

Chondrocranium is a term applied to the parts of any vertebrate skull which pass through, and sometimes remain in a cartilaginous stage. (In Chondrichthyes, the cartilaginous fishes, such as sharks, all the carnium chondrifies and persists in this state . The crania of all land animals, the tetrapods, contain variable regions which ossify directly from mesenchyme. Such dermal (membranous) elements form much of the cranial vault, and in mammals chondrification is limited to the basal regions of the skull. This mammalian change ocurs primarily in three regions (1) caudally, in relation to the notochord; (2) intermediately, in relation to the hypophysis and (3) rostrally between the orbits and the nasal cavities. These may be named parachordal, hypophysial and interorbitonasal regions

In the median plane the cartilaginous centres appear in the base of the skull during the second month in three areas around the Cephalic part of the notochord around the hypophysis cerebri, between the optic and nasal capsules .

(a) The cephalic part of the notochord extends upto the dorsum sellae of the sphenoid bone. This part of the notochord is surrounded by the parachordal cartilages which subsequently unite to form the basal plate. The basal plate is continuous behind with four pre-cervical or occipital scterotomes: the first sclcrotome usually disappears later. The centres of the sclerotome fuse to form the basiocciput: the rudimentary transverse processes unite and constitute the ex-occiput which persists as the jugular processes ;

the laminae of the sclerotomes meet behind forming the foramen magnum and continue further upwards
as the supra-occiput which develops into the squamous part of the occipital bone below the highest nuchal line. The hypoglossal nerve, the nerve of the occipital myotomcs, passes through the hypoglossal canal of the occipital bone; this canal is sometimes divided by a bony spicule, and represents the fused intcrvertebral foramina of the. occipital sclerotomes.

On each side of the basal plate a cartilaginous periotic capsule envelops the membranous otocyst. Each'capsule is perforated medially by the facial and the vestibulecochlear nerves. The otic capsule is separated from the cranial-most occipital sclerotome by a space which forms the jugular foramen for the transmission of the giossopharyngeal, vagus. and accessory nerves. The periotic capsule is later ossified to form the petro-mastoid part of the temporal bone.

(b) A pair of polar cartilages appear by the side of the hypophysis cerebri, and encircle the gland in front of and behind the stalk of the Rathke's pouch. The fused mass thus formed constitutes the posterior part of the body of the sphenoid-bone. The. bottom of the hypophyseal .fossa presents in early embryonic life a cranio-pharyngeal canal .which usually obliterates after third month. The polar cartilages are continuous behind with the parachordal cartilages at the basiocciput. A cartilaginous element, the alisphenoid, develops on each side of the polar cartilages.The alisphenoid forms most .of the greater wing of the sphenoid bone, and is perforated by the maxillary and the mandibular divisions of the trigeminal nerve.

(c) More rostrally a cartilaginous plate, the trabeculae cranii, appears in the median plane. It persists in adult as the cribriform plate of the ethmoid bone. The trabccula is continuous behind with the fused polar cartilages. A nasal capsule is formed by the chondrification around the olfactory placode. Each capsule blends with the ventral surface of the trabeculae cranii; subsequent ossification of the capsule produces the labyrinth of the ethmoid bone and most of the nasal septum.

Lateral to the trabeculae a cartilaginous element, the orbito-sphenoid, develops on each side. The orbito-sphenoid grows medially around the optic nerve and fuses with the polar cartilage. It forms the lesser wing of the sphenoid, and is separated from the alisphenoid by a cleft, the superior orbital fissure. This fissure transmits the oculomotor, trochlear, and branches of the ophthalmic division of the trigeminal nerve.

The ossification of the chondrocranium starts in foetal life, continues after birth and is completed after puberty. At birth, the chondrocranium persists between the basi-occiput and the body of the sphenoid, in the foramen lacerum. in the cartilages of the septum and alae of the nose, and in some less important areas. After the twenty-fifth year, the basiocciput and the body of the sphenoid are united by bony fusion, and the cartilaginous plate disappears.

The parachordal cartilage is developed from the mesenchyme related to the cranial end of the notochord; caudally it exhibits traces of four primitive segments separated by the roots of the hypoglossal nerves. The hypophysial cartilage ossifies to form the postsphenoid part of the sphenoid bone, but its morphological status is uncertain. The interobitonasal cartilage is perhaps equated with the trabaculae cranii of lower vertebrates and is usually known as the trabecular cartilage, which is a bilateral structure developing from two centres of chondrification. The trabeculae cranii may largely be derived from branchial (neural crest) mesoderm, i.e. from the viscerocranium been adapted into the cartilaginous or basal part of neurocranium. from the evidence in embryos of earlier vertebrates most of the chondrocranium and the viscrocranium are derived from neural crest tissue, including almost all of the branchial skeleton. Only the caudal part the trabaculae, the parachordal bars, the otic capsules and second basibranchial appear to be derived from general mesenchyme. . The interorbitonasal cartilage is perhaps equaled with the trabcculae cranii of lower vertebrates usually known as the trabecular cartilage, which is a structure-developing from two centers of chondrification The.trabeculac cranii may largely be derived from branchial (neural crest) mesoderm, i.e. from the viscerocranium, been adapted into the cartilaginous or basal part of neurocranium.

In the human embryo cranial chondrification begins it second month; cartilaginous foci first appear in the occipital one on each side of the notochord (pacachordal cartilages); which later fuse at the end of the seventh week surrounding the notochord, which has an oblique transit through the region . The cartilaginous posterior part of sphenoid is formed from two hypopbysial centres, flanking stalk of the hypophysis and uniting at first behind, then in front enclosing a craniopharyngeal canal containing the hypophysial diverticulum. The canal is usually obliterated by the third month .

The otic capsules, presphenoid, bases of the greater and lesser wings of the sphenoid, and finally the nasal capsule in turn become chondrified. The whole nasal capsule is developed by the end of the third month. . The free borders of the lateral regions of the nasal septum incurve to form the inferior nasal concha during the fifth month and become seperate elements. Posteriorly each lateral part of the nasal capsule becomes ossified as the ethmoidal labyrinth, bearing on the medial ridges the future middle and superior concha.Part of the rest of the capsule remains cartilaginous as the septal and alar cartilages of the nose; part of the rest is replaced by the mesenchymal vomer and nasal bones. the ventral surface of the chondrocranium is associated with cartilages of the branchial arches, The bones ofthe cranial base which are thus preformed in cartilage the occipital (excepting the upper part of its squama), petromastoid part of the temporal, the body, lesser wings, the greater wings of the sphenoid, and the ethmoid. These constitute the cartilaginous part of the neurocranium, the rest which, the mesenchymatous (membranous) neurocranium corresponding to the cranial vault is not preformed in cartilage, frequently described as dermal bones because of their origin , are the frontal bones, the parietals and squamous part of the temporal bones and the upper (interparietal part of the occipital squama). To summarize, therefore the base of the skull except for the orbital plates of the frontals and the lateral parts of the greater sphenoidal wings is preformed in cartilage while the whole of the vault is ossified directly in mesenchyme

Ossification commences before the chondrocranium has developed, and as this change extends, bone overtakes cartilage until little of the chondrocranium remains. However, parts still exist at birth and small regions remain cartilaginous in adult skull. At birth unossified chondrocranium still persists in (i) the alae and septum of the nose, (2) the sphenoethmoidal junction (4) the apex of the petrous bone (foramen lacerum) and (5) between ossifying elements of the sphenoid bone and between elements of the occipital bone. (Most of these regions function as growth cartilages)

MEMBRANE BONES

The bones covering the vault and side wall of the skull are directly ossified in membrane. These consist of the frontal bone including the orbital plates, the parietal, squamous part of the temporal, and interparietal and part of the occipital bones. At birth unossified membranous gaps are found at the four angles of each parietal bone. These unossified membranes known as the fontanelles are altogether six in number – anterior, posterior, a pair of antero-lateral and a pair of postero-lateral. The fontanelles allow expansion of foetal head to accommodate the rapid enlargement of brain which takes place during first year of post-natal life. During parturition the fontanelles also help in moulding of the foetal head by overlapping the skull bones without any undue compression to the brain. Anterior fontanelle is the largest of all, and assumes a diamond-shaped area between the two parietal and the symmetrical half of the squamous part of the frontal bones. All fontanelles, except the anterior, are closed within three or four months after birth. The closure of the anterior fontanelle is usually completed between the second and third years.

MECHANISM OF SKULL FRACTURES

Rowbotham's Hypothesis

This states that fracture of the skull can be caused by direct application of force or by indirect violence.

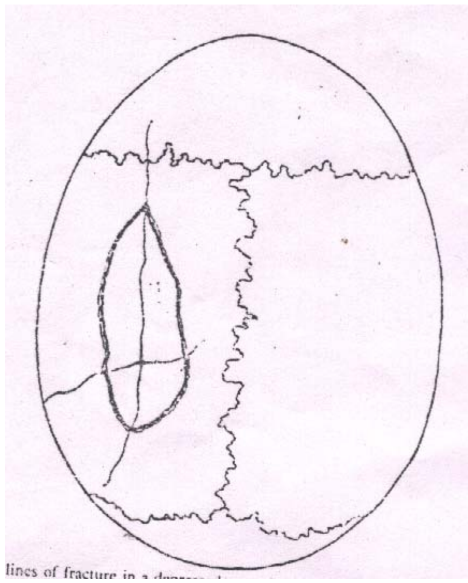
In Direct violence two types of deformation of the skull can occur namely a localized deformation of the skull or a generalized deformation.

LOCAL DEFORMATION.

In local deformation of the skull the skull may yield to the impact producing a bending of the bones of the skull vault without the occurrence of fracture due to limited elasticity of the skull bones. But if the bending is of greater magnitude fracture occurs.

The order of events resulting in a deformation of the skull are as follows:

First, at the site of impact of the bone it is indented into a shallow cone shaped deformity. At the apex of this cone the inner table is stretched and the outer table is compressed. but in the periphery of this deformation the convexity of the bend is directed outwards. In this condition if the elasticity of the bone is not exceeded the bone reverts back to its normal shape on removal of the force, but if the limit of elasticity of the bone is exceeded and if the deformation is of short duration, and results in maximum distortion at the apex of the cone the inner table gets fractured. With greater application of force both the inner and outer tables of the skull may be fractured. The inner table fractures at the apex before the outer table but at the periphery outer table fractures



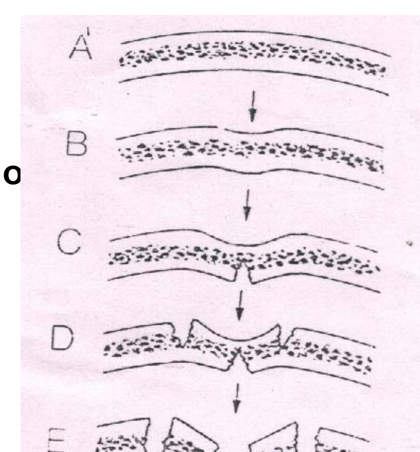
first. These fractures by extension of the outer table fracture through the inner table at the periphery and the extension of the inner table fracture thro

The Lines of Fracture in a depressed comminuted fracture of the skull

A.No

n of Skull without fracture.

inner table,



D Fracture of Inner and outer table.
E. Localized comminuted depressed fracture.
F- Outer Table Crushed in to Diploe

table at the center of the cone indentation results in a depressed comminuted fracture. The depressed comminuted fractures appear as lines radiating from the centre point at the apex towards the periphery and at the peripheral area, as circular fracture lines.

Localized depressed comminuted fractures may occur in association with fissured fractures with general deformation from the same injury. Rarely the spongiosa between the outer and inner tables is fragile and a circumscribed segment of the outer table may be driven into the diploe without disturbing the inner table.

In case of general deformation the skull which acts like an elastic sphere, when comporessed in one plane bulges in other directions for e.g. (1) when the head is compressed between two external objects or between an external object and the spinal column.

(2) When there is a lateral compression of the skull resulting in increase of longitudinal and vertical diameters resulting in fractures occurring along these planes if the bone is stretched beyond its limits of elasticity. The former method is more common than the latter.

The skull bones vary in thickness and strength and relatively weak portions of bones are enclosed within strong ridges and bony buttresses.

The vault of the skull shows vertical thickenings at the glabella, external angular process, the mastoid process and the external occipital protruberance. These vertical ridges are united by three arches on each side namely the Supra orbital ridge in front, the curved lines of the occiput behind and the temporal crests at the sides. There is also a strong antero posterior arch of bone in the midline over the vertex of the skull. The thin place of bone in the base of the skull are enclosed within strong buttresses. The petrous portions of the temporal bones form buttresses on each side and the thickened edges of the wings of the sphenoid form buttresses anteriorly.

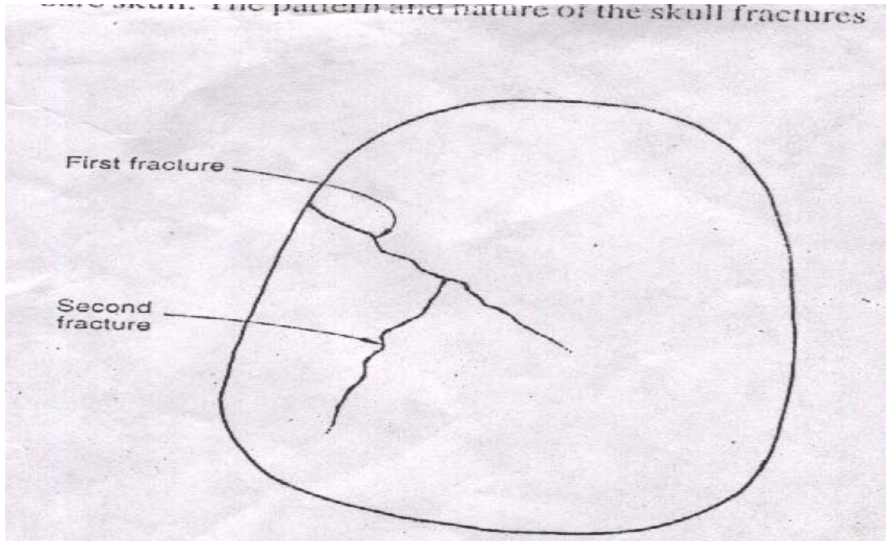
Another factor apart from the anatomical structure of the skull in determining fracture patterns is the mode of application of the force. for. e.g. A force to the glabella region in an upward direction may lift off a dome of bone and cause extensive horizontal fracture which are directed backwards in a direction parallel to the base of the skull.

Fractures of the Skull due to indirect violence.

Fractures of the vault of the skull and the base due to indirect violence may be caused by the forces applied

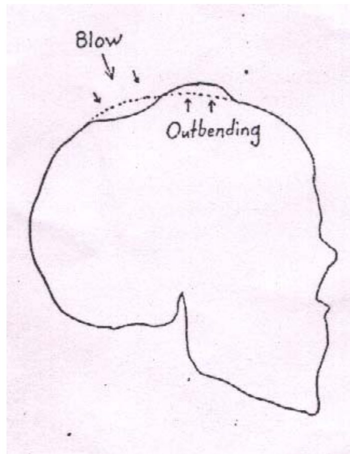
to the face or the chin or by forces transmitted through the spinal column. e.g. in falls from height on to the feet or buttocks.

Types of skull fractures



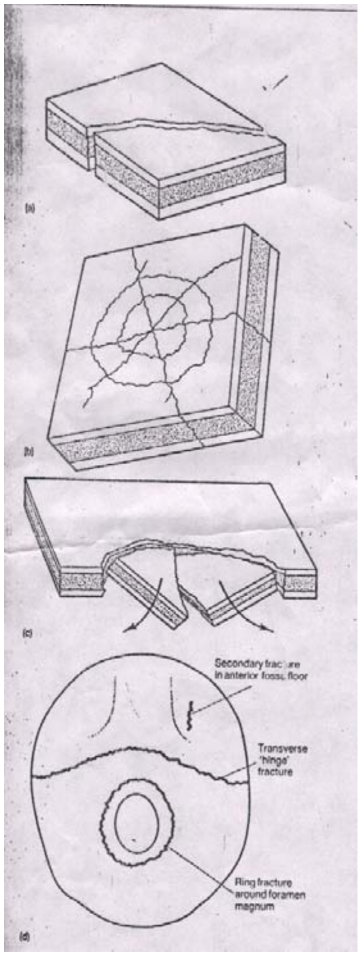
Fissured Fractures of the skull

Fissured Fractures They are produced by general deformation of the skull. These are linear fractures involving the whole thickness of the bone or inner or outer table only. Majority of skull fractures are linear. The outer table is capable of rebounding to its normal shape, while the more brittle inner table fractures. It may be present alone or associated with other types. They are likely to be caused by forcible contact with a broad resisting surface like the ground, blows with an agent having a



Indenting of skull at point of impact with outward bending at periphery

relatively broad striking surface, or from a fall on the feet or buttocks. When a blow is struck on the side and the head is free to move, the fracture starts at the point of impact and runs parallel to the direction of the force. If the head is supported when struck, the fracture may start at the counter-pressure, e.g. in bilateral compression, the fracture often starts at the vertex or more commonly at the base.



Linear Fracture

Spider web fracture

Depressed fracture

Skull base fracture

In both cases, the line of the fracture runs parallel with the axis of compression. A fall on the flat surface may show one or several fracture lines radiating from the point of impact, but the depression of bone fragments is not seen. An extensive haematoma of the scalp will indicate the site of impact. In general, an injury of the head sustained by a fall is mostly situated in the level of the margin of the hat, while an injury due to a blow is commonly situated above this level.

A fracture line tends to follow an irregular course and is usually no more than hair's breadth. Sometimes. a fracture line reaches a suture and follows its course for a while, and then starts again on its own way. The fracture line is often red, but usually there is no haemorrhage. At autopsy, blood can be allowed to run over the suspected fracture which is then washed. Blood will then mark out a fine fracture, which might otherwise be missed. Linear fractures do not tend to cross bony buttresses, such as glabella, frontal and parietal eminence, petrous temporal bone, and occipital protuberance. They tend to cross, points of weakness, such as frontal sinuses, orbital roof, parietal and occipital squama. From the site and direction of the blow on the scalp, one can predict the likely fracture line. A blow over the glabella may cause shattering of the ethmoid sinuses and roof of the nose. In the case of the blow and subsequent fall, the fracture lines produced from a fall are arrested by those produced by the blow. If two blows are struck, the same results are seen and it may be possible to determine which of the blow was first struck.

Anterior blows to the skull produce linear fractures of the orbit, often bilateral and the fractures cross the middle through the cribriform plate, and pass posteriorly through the pituitary fossa into the basal portion of the occipital bone. Blows to the anterior parietal bone produce fracture of the anterior temporal area and with severe violence linear fractures running towards the vertex and the anterior and middle fossae. Interparietal blows produce linear fractures running towards the base, involving the lesser wing of the sphenoid and pituitary fossa. The pituitary and hypothalamus may be damaged (micro-haemorrhages, ischaemic necrosis, avulsion) by blows to the side of the head causing fracture of the middle fossa. With posterior parietal blows, the fracture lines often cross the petrous temporal bone and extend towards the inner ends of the middle fossa into the posterior fossa. Blows on the occipital region produce fractures which extend towards the foramen magnum and often tend to run forwards to the lateral side of the occipital buttress and the foramen itself and may cross the petrous temporal bone and middle fossa. There may be fragmentation of one or both of the orbital plates. Blows high on the vertex tend to produce fractures which cross the midline, sometimes following suture lines. About 20 percent of linear fractures are not found on X-ray.

Fractures of the base which tear the nasopharyngeal mucosa or tympanic membrane produce bleeding from the nose, mouth and ears. Fractures extending across the base of the skull usually run towards and into the formina and damage the structures passing through them by bone deformation and separation.

The human adult head weighs about 4.5 kg. Fractures of the dry skull (i.e. without coverings or contents) can be produce by 3.3 foot-pounds. In the cadaver head about 35 foot-pounds are required to produce a linear fracture of the skull. A linear fracture of skull maybe produced when the head is hit on the side by a stone weighing 90 to 120 g. and when a weight of 2.25 kg is dropped through a distances of one foot.

The first blow to the skull will weaken the structure and subsequent blows may cause a degree of damage out of proportion to the force used, e.g. a second blow on an area of the skull already fractured, may cause widespread collapse of the skull in that area, and the fragments of bone and the weapon itself may be driven far into the brain.

In persons having abnormally thin skull, minor violence may cause a fatal fracture.

(2) Depressed Fractures: They are produced by local deformation of the skull. In this, fractured bone is driven inwards into the skull cavity. The outer table is driven into the diploe, the inner table is fractured irregularly and to a greater extent and may be comminuted. They are also called "fractures a la signature" (Signature fractures) as their pattern often resembles the weapon or agent which caused it. Localised depressed fractures are caused by blows from heavy weapon with a small striking surface e.g. stone, stick, axe, chopper, hammer, etc. Rarely only the inner table may be fractured under the site of impact, leaving intact the outer table. Some times, the depressed fracture may involve the outer table only) A violent blow with the full face of a weapon completely detaches almost the same diameter of the bone, which

is driven inwards. A less violent blow, or an oblique blow, may produce a localised fracture with only partial depression of the bone. When a hammer is used, the fracture is circular or an arc of a circle, having the same diameter as the striking surface, and usually there are no radiating linear fractures. The part of the skull which is first struck shows maximum depression. When the butt of a firearm strikes the skull full faced, the fracture is rectangular, but if only the corner of the butt strikes, the fracture is triangular. Depressed fracture caused by a stone may be irregular or roughly triangular. Ante-mortem fractures in case of homicide often appear as localized depression of the skull. They show a shelving inward of the outer table of the bone along the edges of the fracture.

(3) Comminuted Fractures: In a comminuted fracture there are two or more intersecting lines of fracture which divide the bone into three or more fragments.

They are caused by vehicle accidents, fall from a height on a hard surface, and from blows by weapons with a large striking surface, e.g. heavy iron bar or poker, an axe, thick stick, etc. They may also result from a kick by an animal or by a bullet. It is often a complication of fissured or depressed fractures. When there is no displacement of the fragment, it resembles a spider's web or mosaic. Fissured fractures may radiate for varying distances from the area of comminution (Fragmentation) When the force is great, the broken pieces of bone are displaced and some may enter the brain and others may be lost.

(4) Pond or Indented fractures; This is a simple dent of the skull, which results from an obstetric forceps blade, a blow from a blunt object or forcible impact against some protruding object. They occur only in skulls of infants. The inner table is not fractured, but fissured fractures may occur in the outer table around the periphery of

the dent. The dura mater is not torn and usually the brain is not damaged. In an infant a blow often produces only a dent like that seen in a Ping-Pong ball.

(5) Gutter Fractures: They are formed when part of the thickness of the bone is removed so as to form a gutter, e.g. in oblique bullet wounds. They are usually accompanied by irregular, depressed fracture of the inner table of the skull. The dura mater and brain may be torn.

(6) Ring a Foramen Fractures: It is fissured fracture which encircles the skull in such a manner that the anterior third is separated at its junction with the middle and posterior third. But usually the term is applied to a fracture, which runs at about 3 to 5 cm outside the foramen magnum at the back and sides of the skull, and passes forwards

through the middle ears and roof of the nose, due to which the skull is separated from the spine. The are rare and occur after falls from a height on to the feet or buttocks. In very severe cases, the spine may be driven into the skull cavity, and the vault of the skull may burst open (explosive type) giving the impression of an original massive fracture. A severe blow to the vertex may also cause a ring fracture, but in this case the fracture of the vault will be depressed. A forceful blow on the chin in traffic accident may produce ring fracture, but in this case the fracture of the vault will be depressed. A forceful blow on the chin in traffic accident may produce ring fracture. There maybe laceration of skin but mandible is not fractured in most cases. They are thought to be produced from forces transmitted into the back of the skull through the mandibular joints. They are also caused by a sudden violent turn of the head on the spine, shearing the vault from the base.

(7) Perforating Fractures : These are caused by firearms and pointed sharp weapons like daggers or knives and axe. The weapon passes through both tables of the skull leaving more or less a clean-cut opening, the size and shape of which corresponds to the cross section of the weapon used.

(8) Diastatic or Sutural Fracture : Separation of the sutures occur only in young persons,due to a blow on head with blunt weapon. It may occur alone but often is associated with fracture.

Fracture Base of Skull: basal fractures may be produced by: (1) Force applied directly at the level of the base. (2) General deformation of the skull wherever the forces are applied. (3) Extension from the vault. (4) Force applied to the base through the spinal column or face. In the base, fracture patterns are strongly influenced by the petrous buttress. Fracture lines which approach it from the middle or posterior fossa are turned either towards its apex or base according to the angle at which they strike it. The middle of the body of the petrous bone is fractured only when the force is very great. . Isolated fracture of the base is often due to transmitted force either from the point of the chin or through the spine, except following blows in the temporal region. Fracture lines usually open into the basal foramina. The sphenoidal fissure is most commonly affected. Foramen magnum is not spared in spite of its thickened margins.

Blows on the chin occasionally fracture the glenoid fossa. The force of a blow on the mandible. e.g. an upper cut in boxing, may be transmitted through the maxilla and its internal angular processes to the base of the skull and cause a fracture of the cribriform plate of the ethmoid. An Oblique blow of great force applied to one side of the back of the head will start a fracture in the underlying posterior fossa, which crosses the middle line to enter the middle fossa of the opposite side and may end in the anterior fossa. Longitudinally or transversely directed forces always produce fractures in the corresponding axis. A fall on the back of the head or blow on the top of the head usually produces fractures of the roof of the orbits, especially in old people. These fractures may be comminuted and sometime depressed. These fractures are supposed to be produced from the contrecoup of the orbital lobes of the brain on these paper-thin orbital plates. Sudden violent increase in internal pressure also produces fractures of roofs of orbit, especially in suicidal gunshot wounds of the skull. Fractures of the base of the skull maybe (1) Longitudinal which divide the base into two halves. This may result from a blunt impact on the face and forehead on the back of the head or in front-to-back or back to front compression of the head. e.g. run over by a vehicle (2) Transverse, which divide the base into a front and back half and back half. This may result from an impact on either side of the head or side to side compression of the head as when run over by a vehicle. (3) Ring fractures. Basal fractures are usually associated with cranial nerve damage.

Complications: (1) Fractures of anterior cranial fossa may involve the frontal, ethmoidal or sphenoidal air sinuses, with loss of blood from nose and month (2) If the dura and nasal mucosa are torn CSF and even bran tissue can leak into the nose (3) <u>Leptomeningitis may result due to bacteria</u> passing upwards from the nose

(4) fractures involving paranasal sinuses may cause cranial pneumatocele (5) Fractures of the middle fosa passing through the basiocciput or sphenoid bone may communicate with mouth, from which blood will run. (6) A direct communication between the cavity and the airway via the sphenoid sinus is produced in fracture of

base of the skull involving the sella turcica. Blood may pass into the bronchial tree. Foci of inhaled blood are commonly seen in the lungs which indicate that death was not instantaneous. (7) A fracture of the petrous temporal bone may involve the middle ear, which allows blood and CSF to escape from the ear. The blood may pass into the mouth through the Eustachian tube, and maybe swallowed. Tear of the posterior branch of the middle meningeal artery as it crosses a fracture of the temporal bone produces severe bleeding from the ear. (8) In posterior fossa fractures, extravasation of blood is seen behind the mastoid process or a large haematoma in the soft tissues of the back of the neck. (9) If the fracture reached foramen magnum, cerebellar contusions may result, and the subsequent oedema may herniate the cerebellar tonsils fatally through the foramen . Cranial nerves maybe injured by stretching or bruising but they are usually not severed. Shock,fat and bone marrow embolism can occur.Depressed fractures of skull with laceration of brain may cause severe dysfunction coma and death.

Fracture of the skull occurring opposite to the site of force is known as contrecoup fracture. This usually occurs when the head is not supported. This is explained by the sudden disturbance in the fluid brain content which transmits the force received to the opposite side, where the thrust of violent motion impacts against the cranial wall, which is unable to absorb this degree of disturbance.

SURGICAL IMPORTANCE OF THE SKULL.

The vault of the skull is composed of two compact layers; the outer table (lamina externa_) which is about 1.5 mm thick and the inner table (lamina intema or vitreous layer), which is about O.5 mm thick. Separating the two plates is the diploe, composed of cancellous marrow. The thickness of the skull can vary from 2 to 15 mm. It is thicker in the midsagittal plane and at the occipital protuberance. Because diploe does not form In bones covered by thick muscle, certain regions, such as the squamous temporal and nuchal occipital bones are thin.

The weak points are in the three cranial fossae. The anterior fossa is weak at the orbital and cribriform plates. The posterior fossa is weak at its base and in the area between the mostoid and dural sinus. The middle cranial fossa is considered the weakest.

Most of fractures are linear. The skull is like a semi elastic ball. When a large, low velocity mass strikes the skull, it bends inwared at the impact point and at the same time bends outward around it. When the tensile strength of the skull is exceeded a linear fracture occurs in and extends from the outward bending area.

A depressed fracture is caused by a small mass of high velocity. These fractures are usually comminuted. Some times only the inner table demonstrates such a fracture because of its thinness and shorter radius of curvature than the lamina externa. Any linear area of increased bone density on the routine x-ray should be considered a probable depressed fracture Oblique skull views or preferably CT can usually demonstrate this type of fracture.

A depressed fracture of 5 mm or more has a high association with dural tear. Sometimes the margin of a fracture is elevated owing to rotation of the fragment or an underlying mass effect due to brain edema or hematoma. The opposite nonelevated side may therefore appear (mistakenly) to be depressed.

A diastatic suture is caused by a linear fracture extending into the suture. The lambdoid and sagittal sutures are commonly involved. Diastasis is considered

to be present if the suture is widened greater than 2 mm."

A fracture in me developing skull of a young child can become a "growing fracture" . As a result of an associated dural tear, entrapment of arachnoid in the fracture may occur Cerebrospinal fluid pulsations transmitted through the entrapped lepto- meninges with or without underlying porencephaly or hygroma cause increasing diastasis over time. A palpable bulge of the scalp may be detected. Dural entrapment by itself results only in delayed fracture healing, indicated by months of relatively stable diastasis. Skull fracture in early childhood should heal in a few months; in older children/ it takes a year; and in adults, it averages about 3 years, but evidence of the fracture may still be seen for years afterward. Normal skull anatomy such as vascular grooves, developmental fissures, and the straighter-appearing suture lines of the lamina intema can mimic and be mistaken for fractures. Air trapped in

a scalp laceration, debris, bandages, hair, pins, and so forth can produce unusual markings on skull radiographs.

The imaging of skull fractures in children is subject to ongoing debate. Conventional radiographs are of no benefit in making management decisions for children with minor, low-risk head injuries. All others constitute the higher-risk categories including children younger than 2 years of age and those suspected of child abuse, should have skull radiography, CT, or both. Depressed fractures are best diagnosed by CT

The presence of an opacified or air-fluid level in the sphenoid sinus after head trauma is highly suggestive of a basal fracture. Basal skull fractures can be cryptic therefore/ their true incidence is unknown. CT is more accurate in depicting basal skull injuries than are routine skull radiographs. CT axial and coronal views, with three-dimensional CT reconstruction if necessary, are the best means of diagnosing basal skull fractures.

MRI does not demonstrate bony architecture as well as CT, but it is better than CT at visualizing shear injuries to the brain or subtle subdural and subarachnoid hemorrhage.

Fractures of the cranial vault may extend into the temporal bone perpendicular or longitudinal to the long axis of the petrous pyramid. Longitudinal fractures are usually associated with bleeding from the external ear and possible conductive hearing loss. Transverse fractures can result in neurological defects. If taste and lacrimation are affected, the location of the fracture line is likely proximal to the geniculate ganglion of cranial nerve VII in either the labyrinth or the internal auditory canal. If taste and lacnmation. are normal, the fracture may be distal to the geniculate ganglion, in or near the horizontal or vertical portion of the facial canal.

The tegmen tympani, which is ordinarily very thin can appear discontinuous on .CT coronal sections.

Injuries and deaths caused by falling from a height are by no means uncommon in urbanized areas. Publication on the pathology of such deaths and injuries are scanty, Majority do not clearly describe the pathology of a trauma sustained.

Causation of injuries

The detailed dynamics of vertical deceleration are reviewed in depth in a number of publications. In summary, the amount of tissue injury caused by deceleration alone is determined by the rate of change of both the speed and the direction of the fall.

Bodies generally undergo unrestricted vertical free-fall which is abruptly terminated upon final impact with an firm surface or structure. In the vast majority of cases, the victims tend to land on hard unyielding concrete surfaces, and occasionally on softer grass patches.

However, in a substantial number of cases, the injuries sustained suggest that additional forces, such as those described below, may be involved.

1. Rotation or spiraling of the body during free fall. This may, theoretically, generate sufficient angular momentum to dissipate some of the kinetic energy acquired and thus, the magnitude of primary or final impact.
2. Collision with intermediate structures. These are mainly protruding masonry and such like, which may retard the fall and reduce the final impact velocity. Contact with these structures can itself result in serious injuries such as decapitation, transient impalement of the neck

or trunk or limbs, dismemberment of limbs, and transection of the trunk of the body.

3. Secondary (and possible tertiary) impact with the ground. This is the result of the body bouncing once or several times after the primary impact. Bouncing may dissipate the magnitude initial forces of impact, but is likely to result in more extensive injuries.

It is likely that several mechanisms of injury may operate in a variety of combinations. Thus, apart from the obvious effects of vertical deceleration and direct impact (whether primary or secondary), additional injuries can be caused by outward displacement and secondary penetration by fractured bones producing lacerations to muscle and / or to skin, and compression of the internal organs may be present. In some cases, injuries may also be caused by the so-called " hydraulic ram effect" resulting from the upward forceful acute displacement of the abdominal organs and consequent cardiac injury in the absence of direct thoracic trauma.

DISTRIBUTION OF INJURIES

As one might expect, victims will tend to exhibit extensive and severe injuries in various parts of the body; combined head, thoracic and abdominal injuries are observed in about half of all cases. In general, thoracic injuries are almost universally present, with various combinations of open and / or closed fractures of the long bones, the bones of the feet, and (to a lesser extent) of the hands and pectoral girdle. External injuries, comprising grazes imprint abrasions, scratches, lacerations and bruises, are also almost universal, being absent only in a small proportion (<1%) of subjects who land on a soft surface such as a patch of grass.

Injuries of the head (including the face) and the abdomen are frequently observed – in about 80% of cases, Fractures of the pelvic girdle and the vertebral column (both with and without spinal cord injury) are common, being present in over half and a third of cases, respectively.

THE PATHOLOGY OF INJURIES

Head and facial injuries.

Over one third of victims display cerebral lacerations, usually associated with skull (vault and base) fractures a subset of about 20% of these cases also display massive cranio-cerebral destruction, accompanied by extensive open, comminuted cranial and maxillofacial fractures and partial or complete extrusion of the brain (exanteratio cerebri). A ring fracture of the base of the skull is often seen and this is associated with a laceration or transection of the brainstem (usually at the level mid pons or at the junction between the pons and mid-brain)

Of those who sustain cranio-facial fractures, about one third have an accompanying acute subdural hemorrhage, usually accompanied by acute subarachmoid hemorrhatge while about one third have subarachnoid hemorrhage alone. Epidural (extradural) and intracerebral hemorrhage tend to be relatively uncommon, while cerebral contusion are seen in about one-tenth of cases.

With the exception of patchy acute subarachnoid hemorrhage (mainly over the parasagittal regions) other forms of intracranial hemorrhage are rarely observed in the absence of cranial or facial fractures, or of any direct impact to the head. In such instances, where direct impact to the head is absent, as well as those where laceration of the corpus callosum are present, it is likely that rotational or shearing forces are implicated in the causation. However, in these cases, histological evidence of diffuse axonal injury will usually be difficult or impossible to demonstrate as death would have occurred instantaneously or quite rapidly.

Intrathoracic injuries

Injuries of the thoracic cage.

Approximately 75-80% of victims sustain rib fractures, which are commonly multiple and bilateral. Were the victims to survive the initial or final impact, these multiple rib fractures would result in respiratory embarrassment. The thoracic cage (including the sternum and thoracic spine) is often shattered, resulting in obvious deformation of the chest wall. This tends to occur in falls from heights exceeding 40 m.

Cardiovascular injuries.

Cardiac lacerations or ruptures may be found in about 50% of all subjects. It is observed that the right atrium and ventricle, as well as the interatrial septum, are twice and three times more prone to rupture than the left heart chambers and the interventricular septum, respectively.

This predilection of the right side of the heart to serious or fatal injury may be attributed to the relative fragility of the right heart chambers due to thickness, as well as their vascular attachments (namely the superior and inferior venae cavae) as compared to the left heart chambers (the aorta and the much thicker left ventricular wall) it should be noted that although lacerations of the main coronary arteries may occur, they are invariably accompanied by lethal ventricular, ruptures

Injuries of the heart chambers may be accompanied by lacerations and ruptures of the heart valves. In this respect injuries of the tricuspid and mitral valves are seen with almost equal frequency in about 20% cases of cardiac rupture, and are far commoner than injuries to the pulmonary and aortic valves.

Ruptures of the pericardial sac occur in about one third of all victims, and in almost two thirds of cases with cardiac rupture.

Ruptures of the thoracic aorta are commonly found in about 50% of all victims 70% of ruptures are completely circumferential) 30% are partial. Ruptures tend to occur at the site of junction of the aortic arch with the descending thoracic aorta. This relates to the facts that the aortic arch and the ascending thoracic aorta are relatively mobile within thoracic cavity, while the descending thoracic and abdominal segments of the aorta are firmly adherent or fixed to the vertebral column. As such, the initial segment of the aorta , and the heart to which it is attached continue their descent for a short time after primary impact, thereby causing a tear at the site in question. This explanation appears to be supported by the observation that ruptures of the thoracic aorta heart and pericardial sac often also coexist.

Complete or partial ruptures of the ascending aorta, and the pulmonary trunk, arteries and veins may also be found, although they are substantially less common than those involving the distal part of the aortic arch.

Pulmonary injuries

Pulmonary injuries due to falls from heights and their effects are well documented. The lungs are contused to a greater or lesser extent, in the vast majority of cases. As with cardiac injuries, ruptures or lacerations of the lungs are found in over half of all victims, in whom they are generally associated with rib fractures. In a minority of such cases (10-12%) pulmonary lacerations occur in the apparent absence of injury to the thoracic cage. This is particularly true in children and young adults, whose compliant chest walls appear to be able to withstand significant compression sufficient to disrupt the lungs without fracturing.

Ruptures of the trachea and the principal extrapulmonary bronchi may be seen in 10-15% of cases, where they are usually associated with pulmonary ruptures.

Other injuries.

Other injuries include unilateral or bilateral ruptures of the diaphragmatic dome, together with occasional perforation or rupture of the thoracic esophagus. In children and young adults, the thymus may sometimes be bruised.

Intra abdominal injuries.

Variable combinations of lacerations and more complete transection and ruptures of the liver (60%) spleen (40%) and kidneys (30%) of equally variable severity are observed in victims with abdominal injuries. A combination of liver, splenic and renal ruptures is seen in 10-15% of all victims

These visceral injuries may be associated with ruptures of the retrohepatic inferior vena cava, the hepatic veins or arteries, or the portal vein. Hilar distuption or avulsion of the spleen and kidneys (with or without perinephric hemorrhage) are common. Ruptures of the adrenal glands, pancreas and urinary bladder are found, usually in cases of falls from considerable heights (> 40m) or in association with extensive fractures and deformation of the pelvic girdle. Similarly, probably owing to the intrinsic mobility and compliance of the stomach and intestines only a minority (1-2%) percent with traumatic gastro intestinal perforation these again are highly indicative of falls from heights well exceeding 40-50 m.

Mesenteric bruising, often of a limited extent, is a common finding as is retroperitoneal bruising which tends to be associated with severe pelvic hemorrhage. Partial or complete ruptures of the abdominal aorta may accompany similar injuries of the thoracic aorta.

Hemorrhage.

Hemothorax is found in about two thirds of all victims, either at autopsy or in a minority of cases following thoracic drainage or at surgery. However, in only about one tenth of these cases is more than one liter of blood found in the pleural cavities. Of the minority of all cases (10-15%) presenting with hemopericardium most would have less than 100 ml of fluid blood or blood clots.

Intrathoracic hemorrhage is thus conspicuous by its relative paucity in general or its near absence even in the considerable number of victims who have Intrathoracic injuries. Minimal or no hemorrhage was found in 30%, 40%, 65% and 80% of a series of over 600 victims with fractures of the thoracic cage, pulmonary lacerations, aortic ruptures and cardiac ruptures, respectively.

Mediastinal hemorrhage when present, was largely unremarkable. A similar discrepancy exists between the severity and extent of damage to the abdominal organs and the amount of intra abdominal hemorrhage observed at autopsy over 70% of victims with abdominal injuries showed little or no evidence of hemoperitoneum and none had more than 0.5 L of fluid blood.

There is marked discordance between the degree of internal hemorrhage and the magnitude of the visceral and skeletal injuries sustained which may be attributed to the rapidity with which death would have occurred in the majority of cases. In addition, in an unknown proportion of such fatalities, cardio respiratory arrest, perhaps mediated by some cardiac inhibitory ('vasovagal') mechanism, may have supervened even before primary or final impact with consequent bradycardia or cardiac asystole.

Spinal and pelvic injuries.

Fractures and dislocations of the vertebral column may be found in up to one third of all victims. The thoracic segments appear to be considerably more prone to injury than the cervical and lumbar segments, atlanto occipital dislocation occurs in about 5% of all cases. Combinded cervical thoracic and combined thoracic/ lumbar fracture dislocations occur with about equal frequency 10-15% each. Occasionally, combined fractures of the cervical thoracic and lumbar segments are found. While these injuries usually present as partial or complete disruption of the affected intervertebral disks, the vertebral bodies themselves may be involved. Associated contusions, lacerations, or even traumatic transcetion of the spinal cord are by no means uncommon.

Spinal injuries tend to be associated with pelvic and lower limb fractures, suggesting that they are caused by the vertical transmission of the forces of deceleration upwards along the axial skeleton

Fractures of the pelvic girdle comprise separation of the symphysis pubis, solitary or multiple fractures of the pubic ramin, sacroiliac diastases and some times,

displaced fractures of the ilum. There may also be marked pelvic disruption and deformation, associated with extensive and sever retropubic and retroperitoneal hemorrhage. .

MATERIALS AND METHODS

100 case from fall from Height where chosen during the period between 1-8-03 to 1-12-05 at the Institute of Forensic Medicine Government General Hospital Chennai after obtaining permission from the Director Institute of forensic Medicine Madras Medical College, Chennai.

After getting the requisition from the Investigating Officer and after obtaining the details of the incident from the History of the case the autopsy was started. The Identification marks written in the police requisition were verified with those found on the deceased.

Then a coronal incision was made from one ear pinna to the opposite pinna and the scalp was reflected as two flaps one anteriorly and one posteriorly then the cranial vault was examined for presence of fractures, which if present were noted.

Then the cranial vault was removed by sawing of the skull circumferentially so as to remove a part of the skull as a skull cap. Then the epidural area was checked for any collections of blood (EDH) and then the dura was excised and hemorrhage below the dura was noted (SDH) and below the arachnoid membrane was noted(SAH). The brain was then examined for fracture and dislocations of the vertebrae. The ribs and clavicles and long bones and pelvis were examined for fractures which if presents were noted.

Key

Rt	-	Right
Lt	-	Left
ACF	-	Anterior Cranial Fossa
MCF	-	Middle Cranial Fossa.
PCF	_	Posterior Cranial Fossa.
RR	_	Right Ribs.
LR	-	Left Ribs.
F	-	Frontal Bone.
P	-	Parietal Bone.
T	-	Temporal Bone.
O	-	Occipital Bone
AAL	-	Anterior Axillary line
MAL	-	Mid Axillary Line
PAL	-	Posterior Axillary Line
MCL	-	Mid Clavicular Line
COMM	-	Comminuted Fracture.
L 1/3	-	Lower Third.
U 1/3	-	Upper Third.
M 1/3	-	Middle Third.
BL	-	Brain Laceration.
EDH	-	Extra Dural Hemorrhage
SDH	-	Sub Dural Hemorrhage.
SAH	-	Sub Arachnoid hemorrhage.

RESULTS								
S.No	**Age**	**Sex**	**Height of fall in ft.**	**Description of Cranial Vault Injuries**	**Description of base of Skull Injuries**			
					Anterior Cranial Fossa	**Middle Cranial Fossa**	**Posterior Cranial Fossa**	**Other Injuries**
1004/03	42	M	20	F F Rt T – V 6 cms		F F Rt MCF 6 cms		C Rt T B 4x3x.5 cms
1077/03	12	M	10	FF Lt – Lt O 9 cms			FF PCF – FM 7 cms	F Rt RH
1085/03	35	M	12	Ft LtT T – Lt P 8 cms		FF Lt MCF 6 cms		SDH/SAH BCH
1099/03	2	F	12	D F SS 9 cms		F F Rt MCF – PF – Lt M C F 8 cms		C Rt F 3 x 3 x . 5 cms SDH / SAH B T
1110/03	31	M	8	FF Rt. O – Lt T 17 cm			Comm F O – FM	INF Rt F-C 5X4X1 cm PCL C 2x2x1 cm
1111/03	41	M	15	FF Lt P – Lt T 4 cms		FF Lt MCF 7 cms		SDH/SAH BCH
1178/03	65	M	20	Comm. Rt F TP	Comm. Rt AC F			F Rt R 3,4,5 MCL
1182/03	34	M	11	DEP F – Rt F 5x3x 0.5 cm		FF Lt MCF – Rt MCF 13 cms		

1231/03	$1.^{1/4}$	M	10	FF RtT – Rt P 4 cms F – Lt T – Lt P 6 cms			Tr F Lt PCF- Rt PCF 12 cms	FM 1/3 LC
1292/03	50	M	7	F Lt T 7 cms				F C4 – C5

Key: Tr. Transverse . TB: Temporal base, M1/3 LC : Middle third of Left Clavicle, H: Humerus, DEP: Depressed, DF: Diastatic Fracture, SS: Sagittal suture, BT: Both Temporal Lobes, Comm: Comminuted, C : Contusion, PCL: Posterior Cerebellum. FM: Foramen Magnum MCL : Mid clavicular line

S.No	Age	Sex	Height of fall in ft.	Description of Cranial Vault Injuries	Description of base of Skull Injuries			
					Anterior Cranial Fossa	Middle Cranial Fossa	Posterior Cranial Fossa	Other Injuries
1300/03	18	M	30	FF Rt F – RtP 7 cms FF Lt F– Lt P 9 cms	FF Rt ACF – Lt MCF – PF 12 cms			F RR 6-7 AAL
1335/03	19	M	20	FF Lt T 7 cms			FF Lt PCF – FM 9 cms	SDH –BO
1350/03	40	M	10	FF Lt T – Lt O 10 cms	FF Lt ACF 6 cms			F Lt R 456 - MAL
1358/03	35	M	10	FF Rt T – Rt P 7 cms				COMM L1/3 RH COMM U1/3 RF
1392/03	60	M	10	FF Rt P – O – Lt T 15 cms			FF Rt PCF – FM 13 cms	SDH/SAH RtCH
1396/03	30	M	30	FF Rt F – Rt P 8 cm FF Lt P – Lt O 10 cms				
1402/03	9	M	15	FF Rt P – Rt O 6 cms		FF Rt MCF 7 cms		SDH/SAH BCH
1412/03	28	M	20	FF Rt F – Rt T 7 cms	FF Rt ACF – LT ACF 10 cms			F LF M1/3 SDH/SAH Rt FL & BP

1465/03	45	M	5	FF Rt F –O - Lt P 19 cms		F Rt MCF – Rt PCF 10 cms		L Rt T B 6x5 x1 cm
1470/03	25	M	20	FF Lt F – Lt T 8 cms		FF Rt MCF – PF – Lt MCF 11 cms		L Lt P L 4x2x.5 cm

Key: L: Laceration, TB: Temporal Lobe base, PL : Parietal Lobe, AAL : Anterior Axillary Line, BO : Both Occipital Lobe, MAL : Mid Axillary Line, comm : Comminuted Fracture. L 1/3.RH : Lower third Right Humerus. U 1/3. RF. Upper third Right Femur LF: Left Femur.
CH: Cerebral Hemisphere BP: Both Parietal Lobes FL: Frontal Lobe

S.No	Age	Sex	Height of fall in ft.	Description of Cranial Vault Injuries	Description of base of Skull Injuries			
					Anterior Cranial Fossa	Middle Cranial Fossa	Posterior Cranial Fossa	Other Injuries
1483/03	58	M	20	FF Rt P 6 cms		FF Rt MCF 6 cms		F Rt R 1-4 MAL
1485/03	27	M	30	F F Lt F – Lt P 8 cms		FF Lt MCF 7 cms		C Lt T & Pl 5x4x0.5 cms
1504/03	28	M	10	FF Rt P 7 cms		FF Rt MCF 8 cms		EDH Rt P&Ol 6x5x.5 cm
1510/03	85	M	10	FF Lt T – O 11 cms		FF Lt MCF 4 cms		SDH /SAH B CH
1524/03	13	M	15	COMM Rt T& P 6x4 cms			FF Rt PCF – FM 8 cms	L Rt Pl 4x1x.5 cm
1529/03	8 ½.	M	10	COMM F Lt FTPO			FF Lt PCF 7 cm	SDH/SAH Rt & Lt P & Lt Tl
1532/03	50	M	20	FF Rt T 6 cms		FF Lt MCF to Rt MC F 17 cm		F Lt R 4-7 AAl
1541/03	15	M	15	FF Rt F to Lt T 12 cm		FF Rt MCF 8 cms		SDH/SAH – B CH

1542/03	30	M	40	'C' shaped FF Lt T 10 cms 'L' shaped FF Lt F to Lt T 11 cm		FF Lt F to Lt MCF 12 cms	FF Lt PCF 6 cm	F Rt R 45 MAL F Lt.R 2,3 MAL CL C 4x3x.5
1554/03	45	M	20	FF Rt F to Rt T 8 cms	FF Rt ACF –Pf 7 cms			SDH/SAH B CH

Key: L : Laceration, Pf: Pitutary Fossa, l: Lobe, BCH: Both cerebral Hemispheres, CLC: Cerebellar contusion ,

S.No	Age	Sex	Height of fall in ft.	Description of Cranial Vault Injuries	Description of base of Skull Injuries			
					Anterior Cranial Fossa	Middle Cranial Fossa	Posterior Cranial Fossa	Other Injuries
1571/03	24	M	30		FF Lt ACF 6 cms			F C2, C3 & C7.V
1583/03	42	M	10	FF Lt to 10 cms		F F Lt M C F 6 cms		C Rt F,T , Ol
1584/03	21	M	10	FF Rt T 8 cms		FF Rt MCF 6 cms		EDH Rt.Tl 5x3x.5 SDH Lt P, Tl
1613/03	47	M	25	FF Rt T 8 cms		FF Rt MCF – Pf. MCF 13 cms		F Lt 2,4,5 MAL
1641/03	55	M	20	FF Lt T to O 9 cms	-	-	-	F Lt R 2-7 PAL
1703/03	19	M	30	FF Lt F t O-10 cms	-	FF Lt MCF 5 cms		SAH-Ol,CLC
1705/03	74	M	5	FF Lt T 7 cms		FF Lt MCF 4 cms		EDH Lt T,P,Ol SDH LtP, Tl
1706/03	11	M	10	FF Lt P to 8 cms			FF Lt PCF 7 cms - FM	C –MB 4 x 4 cms x .5 cms

1728/03	45	M	20	FF Rt F 10 cms	COMM F Rt ACF	COM F Rt MCF		EDH Rt F,T,P,OL.
1740/03	30	M	13	FF Rt T – 8 cms		FF Rt MCF – Rt PCF 15 cms		F Rt. R 8,9,10 MCL

Key: CLC : Cerebellar Contusion, V: Vertebrae, l,: Lobes , MCL Mid Clavicular Line.

S.No	Age	Sex	Height of fall in ft.	Description of Cranial Vault Injuries	Description of base of Skull Injuries			
					Anterior Cranial Fossa	Middle Cranial Fossa	Posterior Cranial Fossa	Other Injuries
1842/03	50	M	10	FF Lt T 4 cms long			F F PCF to F M 8 cms	F Lt R 1-6 AAL
26/04	38	M	30	FF RtF to Rt. T 12 cms			FF Rt PCF - FM 10 cm	SDH/SAH BCH
27/04	37	M	20	FF Lt T 7 cms	FF Rt ACF 3 cms			F Rt. R 4-10 MAL F Lt R 2-10 AAL
40/04	2 ½.	F	15	FF Lt O to Rt F 8 cms				SDH/SAH BCH
43/04	35	M	20	FF Rt T to Rt P 9 cms		FF Rt ACF to Rt MCF 14 cms		IVH
199/04	45	M	20	Comm F Rt F 5x3 cms	Comm F Rt ACF			L Rt Fl 2x1x.5cms
208/04	35	M	20	FF Lt T-Lt P 10cms				F Rt R 9,10,11 MCL
211/04	55	M	10	FF Lt T to Lt P 8 cms		FF Lt MCF 5 cms		C Lt P,Rt P&Rt Tl
230/04	42	M	10	FF Lt F to Lt P 7 cm		FF Lt MCf 3 cms		F C 4,C5 V

265/04	50	M	20	Rt F to Rt P 11 cm	FF Rt ACF F-3 cms			C L C 6x3x.5 cms, F L2 V

Key: CLC : Cerebellar Contusion, C: Contusion, l: Lobes. L2: Second lumbar, V : Vertebra.

S.No	Age	Sex	Height of fall in ft.	Description of Cranial Vault Injuries	Description of base of Skull Injuries			
					Anterior Cranial Fossa	Middle Cranial Fossa	Posterior Cranial Fossa	Other Injuries
267/04	6	F	3				FF PCF to FM9 cm	SL C1 over C2 V
275/04	48	M	30	FF Rt T to Lt O 12 cm				SDH/SAH BCH
289/04	31	M	15	FF Rt T to mid line P 8 cms FF Rt P to Midline 4 cms				C Rt Fl & Lt F l 8x6x 1 cm, 6x5x 1 cm
290/04	33	F	50	FF Rt F – Rt T 7 cms				F Lt R 3-8 MCL
296/04	45	M	6	FF Rt T to Rt P 6 cms		FF Rt MCF - Lt - MCF 14 cms		F OU 1/3 Rt Cv
302/04	42	M	10	FF Mid F to Vertex 11 cms				F C4,C5 V
305/04	13	F	10	FF Lt T to Lt O 9 cms	FF Lt ACF 10 cm			C B LT Fl & Lt T l 12 x 10 x .5 cms
376/04	35	M	20	FF Lt P – Lt O 8 cm				SDH /SAH BCH

380/04	55	M	30	FF Lt T 7 cm		FF Lt MCF 5 cm		F Lt R 4& 5 MCL
381/04	19	M	40	FF Lt P – Vertex 9 cms	FF Lt ACF 4 cms	FF Lt MCF 6 cms		EDH Lt Pl 5 x 5 x .2.5 cms, C LT,Pl 5 x 3x .2.5 cms

Key : l: Lobes SL: Subluxation. OU1/3 : Outer third. V: Vertebra. C: Contusion.

S.No	Age	Sex	Height of fall in ft.	Description of Cranial Vault Injuries	Description of base of Skull Injuries			
					Anterior Cranial Fossa	Middle Cranial Fossa	Posterior Cranial Fossa	Other Injuries
384/04	26	M	30	FF Rt T 7 cms		.FF Rt MCF 7 cm		SDH /SAH – BCH
398/04	20	M	20				FF Rt PCF to F.M	EDH Rt & Lt Ol
429/04	45	M	25	FF Rt F 4 cm	FF Rt ACF 5 cm			L Rt P 6x3x.5 cm
541/04	25	M	25	FF Rt F to RtO 14 cm				C (L&R) T,P,Ol. 11x8x.5 cms
544/04	21	M	10	FF Rt T 4 cm			FF PCF 7 cm - F.M.	F Rt R 1-4 AAL
569/04	85	M	6	FF Lt T to Lt P 7cms	COMM F Lt ACF			F Rt R 2,3,4 MAL F Lt R 3,4,5 MAL
570/04	45	M	6	FF Lt T 5 cm		FF Lt MCF 4 cms		C Lt. Tl 3x3x.5 cm
576/04	40	M	20	COMM Rt F – Rt P	-	FF Rt MC F. F 6cm		SDH/SAH BCH
720/04	25	F	20	FF Rt FTP	FF Rt ACF FF 8 cm	FF Rt MCF	FF Rt MCF to Rt PCF 7 cm	C Rt Tl 5x4x.5 cms

765/04	33	M	8	-	-	-	FF Rt PCF 14 cm	CLC 4x4x.5 cms

Key: C Contusion. CLC Cerebellar Contusion. MAL : Mid Axillary Line.
AAL Anterior Axillary Line

S.No	Age	Sex	Height of fall in ft.	Description of Cranial Vault Injuries	Description of base of Skull Injuries			
					Anterior Cranial Fossa	Middle Cranial Fossa	Posterior Cranial Fossa	Other Injuries
950/04	52	M	-	-		FF Rt MCF – Lt MCF 12 cm		C T l Rt, Lt 7x5x.5 cms,6x5x.5 cms
1071/04	13	M	10	FF Lt T 4 cm	FF Lt ACF – Rt ACF 14 cm			L Fl Rt, Lt, 3x2x.5 cms, 4x3x.5 cms
1345/04	25	M	12	FF Rt P 5 cm	FF Rt MCF – Lt MCF 11 cm			C Rt Tl,. 5 x 2 x..5 cm
1358/04	39	M	8	FF Rt T 10 cm				SDH/SAH BCH
1370/04	20	M	30	COMM F Rt FTP 9x 5 cm			FF Rt PCF 5 cm	L Rt Ol 6x5x.5 cms, CLC 6x4x.5 cms
1386/04	2 ½	M	40	COMM Rt FTP 9x8 cms			FF PCF-T	CLC 11x8x2 cms
1395/04	16	M	25	F F Rt F T P 20 cm		FF Rt MCF 6 cm		SDH / SAH Tl Rt, Lt 7x5x.5 cms, 6x4x .5 cms
7/05	49	M	3	FF Rt F T P 17 cm				SDH/SAH BCH
39/05	28	M	12	F F Lt F T P 15 cm	Comm F Lt ACF	FF Lt M CF – 6 cms		SDH/SAH BCH
82/05	25	M	20		F F Lt ACF 9 cm	FF Rt MCF – PF - Lt MCF 13 cms		C Tl Rt, Lt 6x5x.5 cms, 7x5x.5 cms

209/05	53	M	10	FF Rt F T Vx 9 cm	FF Rt ACF 8 cm			L Rt. Fl 5x4x1 cm

Key: C: Contusion, L, Laceration, BCH: Both Cerebral Hemispheres VX: Vertex. l; Lobes

S.No	Age	Sex	Height of fall in ft.	Description of Cranial Vault Injuries	Description of base of Skull Injuries			
					Anterior Cranial Fossa	Middle Cranial Fossa	Posterior Cranial Fossa	Other Injuries
244/05	75	M	15	C S D 7 cm S.S D. 6 cm				F Rt R 3,4,5,MAL
289/05	48	M	6	COMM Both . F & Both P	FF ACF 6 cm	H.F Rt. MCF to Lt MCF 12 cm		EDH BCH
418/05	48	M	8	C S D 14 cms COMM .F & Lt F. Lt. P		FF L MCF 8 cm F F R MCF 3 cm		SDH/SAH BCH
426/05	45	M	20	FF Rt T 5 cm		F Lt MCF 6 cm		F Rt R 1-7 MCL L Lt T 6x8x.5 cms
448/05	40	M	20	F Lt P to Lt T 8 cms				EDH MP 3x3x.5 cms F Rt R 4-8 MAL
507/05	48	M	30	FF Rt T 7.5 cm	-	-	-	F Rt Fr. M 1/3
596/05	2 ¼	F	10	SSD 4 cms	-	-	-	E DH BCH 5x4x.5 cms

644/05	45	M	10	FF Lt T 4 cms		Rt MCF – Lt MCF 17 cm		C Tl Lt & Rt 7x5x.5 cms, 6x5x.5 cms
656/05	7	M	20	FF Lt T 7 cm F.F. Lt. F-Rt T 21 cms		FF Lt.T to Lt MCF 11 cm		C Tl Rt & Lt 6x4x.5 cms, 5x3x.5
758/05	48	F	10		-	-	-	F D12, D Rt HJ

Key : C. Contusion. L: Laceration. F: Fracture. V: Vertibra. MP: Mid Parietal. Fr: Femur. D: Dislocation. HJ: Hip Joint

S.No	**Age**	**Sex**	**Height of fall in ft.**	**Description of Cranial Vault Injuries**	**Description of base of Skull Injuries**			
					Anterior Cranial Fossa	**Middle Cranial Fossa**	**Posterior Cranial Fossa**	**Other Injuries**
815/05	60	M	12	FF F.Rt P - Rt.T 8 cm	FF Rt ACF 4 cms			C Rt. Pl & Tl , .2x1x1 cms, 1.5 x 1 x 1 cm
825/05	21	M	5	FF Rt P – Rt O 8 cm		FF Rt MCF – Lt MCF 11 cm		F Rt R 1 & 2 MCL F Rt R 3,4,5 MAL
1576/05	67	M	20	D F Rt . FTP 10 x 8 x .5 cms		FF Rt MCF-Lt MCF 14 cm		C Tl Lt, Rt 3x3x.5 cms, 3x2x.5 cms
1595/05	24	M	10	‘C’ Shaped FF RT FTP 20 cms		FF Rt MCF 7 cm long		L Rt Tl 3x2x2 cms
1616/05	40	M	10	FF Rt T 5 cms FF Lt.F 6 cms		FF Lt ACF – Rt PCF 19 cms		C Lt Fl 3x2x.5 cms C Rt Tl 5 x 3 x .5 cms

1891/05	19	F	50	FF Rt P 5 cms		FF Rt MCF 7 cms		SDH/ SAH Rt Tl 6 x 3 x .5 cms
1892/05	45	M	10	FF Lt F to Lt O 13 cms				SDH /SAH BCH
1981/05	53	M	7	FF Rr F to Rt. P 7 cms		FF Rt. MCF – l. MCF 11 cms		C Tl Rt, Lt, 2 x 2 x .5 cm, 3 x 2 x .5 cms
1984/05	30	M	20	FF Lt T 7 cms		FF Lt MCF Pf –Rt. MCF 14 cms		SDH/SAH Tl Rt & Lt

Key: FF: Fissure Fracture, L: Laceration, C: Contusion Pf: Pitutary Fossa. l: Lobes.

DISCUSSION

(I) Study of various types of skull fractures

In almost all previous studies regarding cases of fall from height the authors mentioned about only two types of skull fractures (depressed fractures of the vault, Ring fracture of the base of the skull)

In this present study irrespective of age and sex 99% of fall from height cases had skull fracture and atleast four types of skull fractures were found.

1. Fissure fracture 86% (Vault and Base)
2. Depressed Fracture 2%
3. Comminuted Fracture 8%
4. Diastatic Fracture 4%

In the vault of skull the fissure fracture involved one (or) two bones and in the base of the skull it involved one (or) two cranial fossae

Vault Fractures Single Bone Involvement	No.of cases
1. Frontal	2
2. Parietial	2
3.Temporal	22
4. Occiptal	Nil
Vault fractures Two bone involvement	
1.Temporal and Parietal	9
2. Temporal and Occipital	5
3.Frontal and Parietal	8
4. Parietal and Occipital	5
5.Frontal and Temporal	4

Base of skull fractures one cranial fossa involvement	No.of cases

1.Anterior Cranial fossa	9
2. Middle Cranial fossa	42
3. Posterior Cranial fossa	14
Base of Skull fracture Two Cranial fossae involvement	No. of Cases
1. Anterior and Middle fossae	2
2. Middle and posterior Fossae	3
Base of skull fracture Anterior, middle and posterior fossae	1

Isolated base of skull fractures without vault involvement - 6 .

Isolated vault fracture without base of skull involvement - 19

II. <u>Correlation of brain injuries with skull fractures</u>

Brain Injuries	No.of cases
1. Brain laceration	9
2. Brain contusion	25
3. Meningeal Hemorrhage	35

Out of 99 cases of skull fractures 69 cases had brain injuries.

III. Study of fractures other than skull.

Bone Fractures	No.of cases
1. Cervical vertebrae	6
2. Thoracic vertebrae	1
3. Clavicle	2
4. Ribs	16
5. Femur	3
6. Humerus	2

Out of 100 cases of fall from height 29 cases had both skull and bone fractures whereas in one case there was no skull involvement.

IV. <u>Correlation of height of fall with skull fractures</u>

In this study the minimum height of fall is 3 feet, which had a 17 cm long fisher fracture involving right fronto parieto temporal bones whereas in the case of fall from height of 10 feet no skull fracture was found.

CONCLUSION

Irrespective of age and sex 99 % of cases of fall from height resulted in skull fracture.

About 86% of skull fractures were fissure fracture In the vault of the skull temporal bone is involved in majority of cases and in the base of the skull the middle cranial fossa is involved in majority of cases.

Out the skull fracture cases only 69 cases had brain injuries.

There was no definite correlation between height of fall and the severity of the skull fractures.

This study conforms with the observation given in Youman's text book of Neurosurgery that the middle cranial fossa is the weakest portion of the skull.

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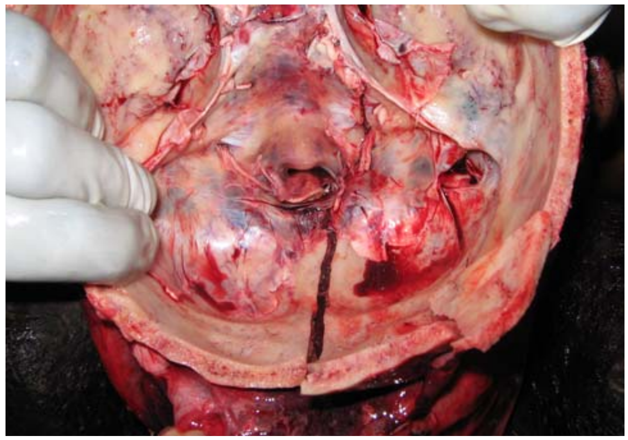
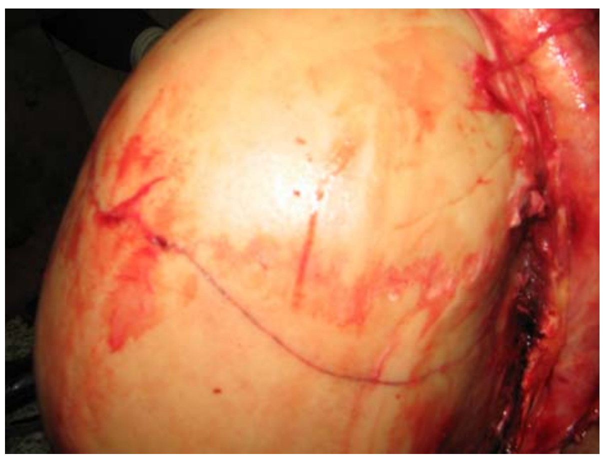
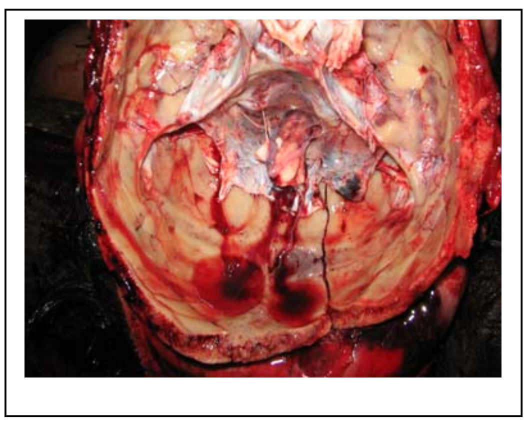


FISSURE FRACTURE OF POSTERIOR CRANIAL FOSSA
EXTENDING TO FORAMEN MAGNUM



FISSURE FRACTURES OF RIGHT TEMPORAL BONE
EXTENDING TO THE RIGHT PARIETAL BONE

PM. NO. 381/04
FISSURE FRACTURE OF LEFT ANTERIOR CRANIAL FOSSA



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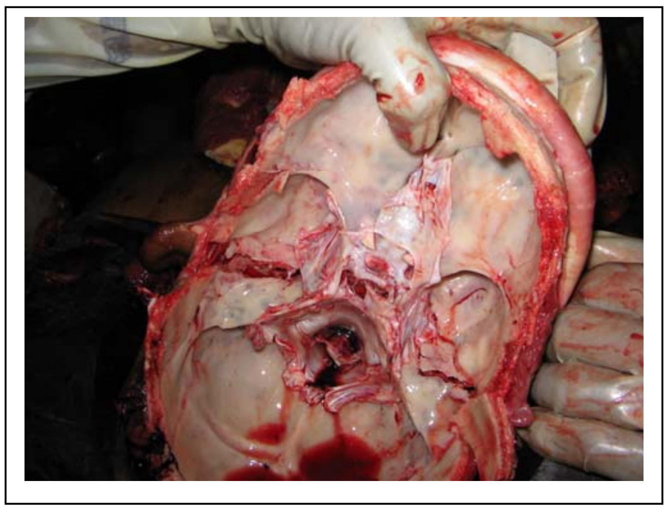

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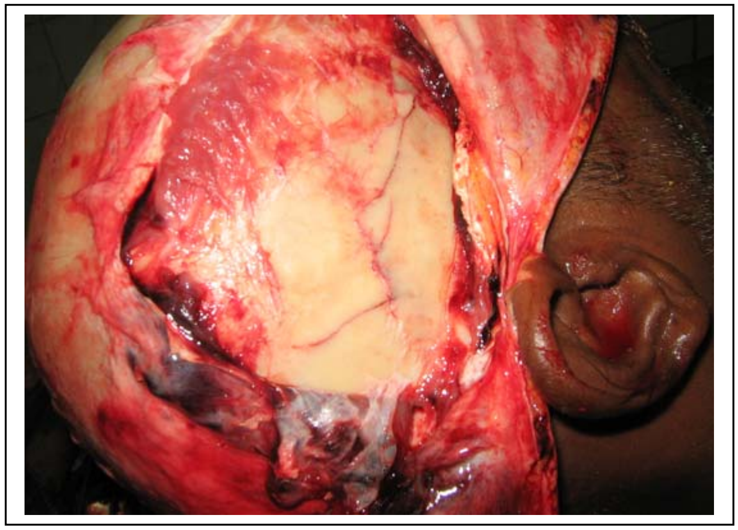

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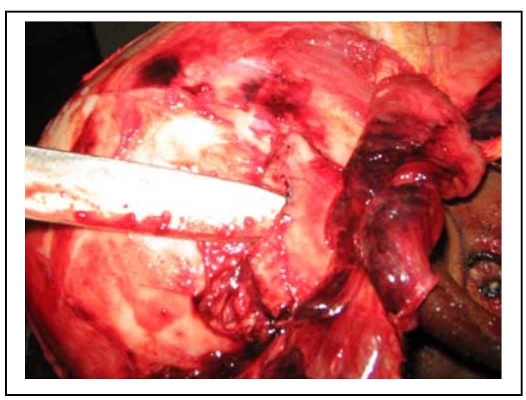

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